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The effect of cane girdling on berry skin phenolic concentration of three table grape varieties

A szálvesszőgyűrűzés hatása a bogyóhéj fenolos koncentrációjára három csemegeszőlőfajta esetében

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ABSTRACT

The effect of cane girdling on grape skin phenolic composition and concentration was examined on three Hungarian table grape varieties, i.e. noir-skinned 'Esther', rose-skinned 'Lidi', and blanc-skinned 'Fanny'. Girdling was conducted at the BBCH 75 phenological growth stage (pea-sized berries). A significant increase was observed in anthocyanin-glycosides in the treated berry skins irrespective of the cultivar. Other phenolic substances (gallic acid, *trans*-resveratrol, (+)-catechin, quercetin-3-glucuronide) were less sensitive to the treatment, but noticeable differences were found between the genotypes.

Keywords: Esther, Lidi, Fanny, anthocyanin, phenols

ABSZTRAKT

A szálvesszőgyűrűzés hatását elemeztük a bogyóhéj fenolos mennyiségi és minőségi mutatóira nézve három magyar nemesítésű csemegeszőlőfajta kapcsán. A sötét bogyójú 'Esther', a rózsaszín bogyójú 'Lidi' és a fehér bogyójú 'Fanny' kerültek vizsgálatra. A gyűrűzés a BBCH skála szerinti 75. fenológiai stádiumban (zöldborsó méretű bogyók) került kivitelezésre. Szignifikáns növekedést tapasztaltunk a kezelés hatására az antocianin-glükozidok esetében szőlőfajtától függetlenül. Az egyéb fenolos összetevők (galluszsav, *transz*-rezveratrol, (+)-katehin, kvercetin-3-glükuronid) kevésbé voltak érzékenyek a kezelésre, de az egyes genotípusok között észrevehető különbségek adódtak.

Kulcsszavak: Esther, Lidi, Fanny, antocianin, fenolok

INTRODUCTION

Cane girdling is an ancient horticultural technique, which is used to improve fruit quality and yield in many plant species (Goren et al., 2003). It is also applied to grapevines and its timing plays an important role in modifying berry size and quality. Early girdling carried out after flowering improved fruit set, grape berry size and berry weight (Brown et al., 1988; Carreño et al., 1998; Williams and Ayars, 2005). On the other hand, girdling at veraison stimulated ripening, enhancing berry colour development and sugar accumulation (Peacock et al., 1977; Roper and Williams 1989; Carreño et al., 1998). It was shown that the translocation of carbohydrates and other assimilates from leaves to roots is temporarily inhibited by girdling (Roper and Williams, 1989), which can impair the condition of the whole plant. In this sense, girdling should be practiced with caution in newly planted and/or weakly conditioned vineyards (Goren et al., 2003; Yamane and Shibayama, 2006; Li et al., 2015). The effect of girdling on grape phenolic components, especially on anthocyanins, is poorly studied and some experiments were carried out on a few grape cultivars (Ferrara et al., 2014; Li et al., 2015). In these studies, the results reflect an increase in skin phenolic concentration of the grape, however the examined phenolic components were limited (anthocyanins, quercetin). The aim of this study was to present more detailed results on the impact of cane girdling on phenolic concentrations (18 phenolic components were examined including anthocyanins) and composition of three inter-specific Hungarian table grape varieties. Inter-specific varieties with increased fungal disease resistance are also known as PIWI grapes (ger. *pilzwiderstandsfähigen Rebsorte*) in German speaking countries.

MATERIALS AND METHODS

The experiment was carried out at the NARIC Research Institute for Viticulture and Enology (Kecskemét-Katonatelep, Hungary) in 2011. Noir-skinned 'Esther' ('Seyve-Villard 12375 Eger 2' x 'Magaracsi csemege I.'), rose-skinned 'Lidi' ('Seyve-Villard 12375 Eger 2' x 'Magaracsi csemege III.'), and blanc-skinned 'Fanny' ['Seyve-Villard 12375 Eger 2' x ('Téli muskotály' x 'Olimpia')] varieties were studied. All of them are inter-specific hybrid table grape varieties with disease resistant characteristics (against powdery mildew, downy mildew and botrytis). The vines were cultivated on sandy soil using a "*Pendelbogen*" training system, and planting material were own-rooted vines on a sandy soil. The spacing was 3 m x 1 m with a Northwest-Southeast row orientation. The vines for the experiment were selected at random, avoiding the marginal plots. Girdling was conducted at the BBCH 75 phenological growth stage (pea-sized berries) with a professional cane girdling on the internode after the second bud on the arched cane, thereby removing phloem tissues. The girdled ring was 4 mm wide. The harvest was carried out at the end of August in the case of 'Esther' and 'Lidi'. 'Fanny' was picked one week later. Fifteen bunches were collected from each treatment and each variety from 5-5 stocks, respectively. Altogether 60 berries per treatment (four berries from one bunch) were taken from the bottom part of the bunch with similar size and position and were used for basic analytical measurements for each replicate (n=3). Another 30 berries (10 per a replicate) were weighed. Skins of these berries were pealed in order to measure skin phenolic composition. Our goal was to ensure the homogeneity and comparability of the samples. The microclimate and the exposure of the cluster, the position on the vine, and even the position of the berries within the cluster can have a significant effect on phenolic composition (Haselgrove et al., 2000; Kontoudakis et al., 2011). In order to minimalize the numerous non-treatment factors, the berries on the field were taken from the same position, bottom of the bunch. Letaief et al. (2008) described this sampling position as "G3 bottom".

Grape skin extracts for analysis of phenolics were made according to Sun et al. (1996) and HPLC quantification was carried out by using the method of Iacopini et al. (2008) modified to a Kinetex™ 2.6 µm C18 100 x 4.6 mm column in an HP1100 system. Statistical analyses were conducted by the Sigma Stat (Systat Software Inc., San Jose, CA, USA) 8.0 software and Tukey's multiple range test was used for mean separation.

RESULTS AND DISCUSSION

In the case of 'Lidi' and 'Fanny' varieties, girdling had a positive effect on cluster, rachis, and berry weight, however, significant differences were only found in few cases between the treatments. Interestingly, girdling had no effect on any of these parameters by 'Esther'. Similar results were obtained in the case of berry sugar concentration (Esther control: 194.4 g/L; Esther girdled: 210.9 g/L; Lidi control: 188.0 g/L; Lidi girdled: 176.7 g/L; Fanny control: 150.6 g/L; Fanny girdled: 144.5 g/L). Sugar concentration was increased by the treatment in the case of 'Esther', and titratable acidity was higher in the girdled 'Lidi' and 'Fanny', compared to the control (Esther control: 6.2 g/L; Esther girdled: 5.8 g/L; Lidi control: 9.1 g/L; Lidi girdled: 12.7 g/L; Fanny control: 6.2 g/L; Fanny girdled: 7.5 g/L).

Anthocyanin profiles are shown in Table 1. A significant increase was observed in anthocyanin-glycosides in the treated berry skins, irrespective of genotypes. This finding is in accordance with other observations (Carreño et al., 1998; Singh Brar et al., 2008). In our study petunidin was the most abundant anthocyanidin by 'Lidi' (Table 1). Contrary to the general trend, malvidin can be described as the major anthocyanidin in noir- or rose-skinned grape varieties (Monagas and Bartolomé, 2009), but this compound is almost totally absent in rose-skinned 'Lidi'. Girdling had a visible effect on anthocyanin accumulation; however, other phenolic substances were less sensitive to the girdling treatment.

Significant differences were only found in some phenolic components (Table 2). No (-)-epicatechin, *trans*-piceid or *trans*-resveratrol was observed in the grape skin extracts of 'Lidi' and 'Fanny'. *Trans*-caffeic acid and *trans*-p-coumaric acid were also undetectable by these varieties. 'Esther' cultivar had the highest total flavonoid and non-flavonoid concentration. 'Esther''s skin (+)catechin concentration was not influenced by this treatment, but the amount of (-)-epicatechin increased due to girdling. Resveratrol and piceid concentrations remained constant in all cultivars. Hydroxycinnamic and dihydroxybenzoic acid concentrations increased after girdling, with significant differences between the control and the treated berry skin samples (Table 2). A study done by Singh Brar et al. (2008) showed that girdling did not influence quercetin accumulation. Similar results were obtained in our study. Although, a slight increase in flavonol (quercetin, kaempferol) concentration was found, the differences in these parameters were not significant between the treatments.

Table 1. Anthocyanin concentrations in berry skins

mg/kg skin FW	Del-3-G	Cya-3-G	Pet-3-G	Peo-3-G	Mal-3-G	Σ
Esther control	222±32^{b}	67±20^{b}	377±47^{b}	92±13^{b}	576±70^{b}	1333±13^{b}
Esther girdled	281±47^{a}	90±21^{a}	482±77^{a}	130±19^{a}	687±67^{a}	1669±19^{a}
Lidi control	13±4^{b}	4±4^{b}	79±27^{b}	1±1^{a}	2±1^{a}	98±34^{b}
Lidi girdled	30±11^{a}	13±8^{a}	189±60^{a}	3±2^{a}	4±2^{a}	239±83^{a}

Del-3-G: delphinidin-3-glucoside; Cya-3-G: cyanidin-3-glucoside; Pet-3-G: petunidin-3-glucoside; Peo-3-G: peonidin-3-glucoside; Mal-3-G: malvidin-3-glucoside.

Values marked with different Roman letters mean significant differences between the treatments. For mean separation, Tukey's test was used at P=0.05. Each value represents the average ± standard error of 3 replicates.

Table 2. Phenolics composition of berry skins

mg/kg skin FW	GA	PrA	CA	VA	*t*CAA	pCA	HYP	MiQ	K3G	CAT	eCAT	*t*P	*t*R
Esther control	28±4^{b}	18±1^{a}	6±11^{b}	32±9^{b}	81±19^{b}	54±16^{b}	113±41^{a}	223±64^{b}	265±195^{b}	39±12^{a}	224±109^{b}	41±14^{a}	4±2^{a}
Esther girdled	38±9^{a}	25±9^{a}	30±3^{a}	57±21^{a}	135±33^{a}	91±31^{a}	164±65^{a}	319±72^{a}	446±115^{a}	54±19^{a}	477±133^{a}	50±16^{a}	5±3^{a}
Lidi control	8±2^{a}	25±5^{b}	52±13^{a}	n.d.	n.d.	n.d.	46±25^{a}	55±28^{a}	110±62^{a}	21±6^{a}	n.d.	n.d.	n.d.
Lidi girdled	7±2^{a}	42±8^{a}	53±8^{a}	n.d.	n.d.	n.d.	55±28^{a}	55±12^{a}	102±53^{a}	28±4^{a}	n.d.	n.d.	n.d.
Fanny control	5±2^{a}	16±4^{b}	n.d.	32±5^{a}	n.d.	n.d.	23±3^{a}	58±10^{b}	306±70^{a}	9±1^{a}	n.d.	n.d.	n.d.
Fanny girdled	7±1^{a}	25±3^{a}	9±1	40±8^{a}	n.d.	n.d.	29±7^{a}	71±17^{a}	371±118^{a}	7±1^{a}	n.d.	n.d.	n.d.

GA: Gallic acid; PrA: Protocatechuic acid; CA: caftaric acid; VA: Vanillic acid; tCAA: *trans*-caffeic acid; pCA: *trans*-p-coumaric acid; HYP: hyperoside/quercetin-3-O-galactoside; MiQ: quercetin-3-glucuronide; K3G: kaempferol-3-O-glucoside; CAT: (+)-catechin; eCAT: (-)-epicatechin; tP: *trans*-piceid; tR: *trans*-resveratrol; n.d.: not detectable

Values marked with different Roman letters mean significant differences between the treatments. For mean separation, Tukey's test was used at P=0.05. Each value represents the average ± standard error of 3 replicates

CONCLUSION

Girdling had a moderate effect on phenolic concentration of the studied grape varieties. Anthocyanins and some flavonol concentrations of the berry skins were increased significantly due to the treatment, which may improve the health benefits as fresh food. However, the growers have to take into account that girdling may decrease the condition of the whole plant. It is recommended to continue such experiments with the same varieties in different vintages, under distinct climatic conditions, and terroirs, because these factors may also have a significant effect on the set of investigated parameters such as phenolic compounds.

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